9-14-95
(ADD 6929)

17th Street Canal East Bank Floodwall Capping
DACW29-93-C-0081

Canal Side Formwork Movement
of
An Uneven Leg I-Wall
Prior to and During Placement of Concrete

Background Information

This paper concerns the formwork movement of the uneven legged I-wall located between Hammond Highway and Veterans Boulevard on the East Bank of the 17th Street Canal. The I-wall is part of the 17th Street Canal Floodwall, East Bank construction project in Jefferson Parish, Louisiana.

The contractor claimed that the original sheet piling is deflecting towards the canal side when subjected to the wet concrete pressure, causing the reinforcing to move and thus causing the formwork to move. In order to construct the wall within the specified tolerances (1/2 in.), the contractor elected to push the formwork between 3/4 in. and 1 in. towards the landside prior to placement of concrete.

The sheet pile was not designed to be connected to the reinforcing or the formwork. Therefore any movement of the sheet pile within the formwork prior to and during placement of the wet concrete should not affect the formwork.

As specified the contractor submitted the formwork analysis. The formwork was found to be structurally sound. The contractor did not submit any analysis of the formwork support system.

The formwork support system consists of a bracing system on the flood side of the formwork only. The system consists of a horizontal non-adjustable strut, an adjustable diagonal strut, a horizontal beam, and a cofferdam sheet pile wall. The struts are 2 inch schedule 80 pipes and are adequate. The horizontal beam is a wide flange section and is adequate.

The cofferdam sheet pile wall was designed and built by the contractor. The contractor submitted the cofferdam design. The cofferdam sheet pile wall was included to provide the contractor a "dry" working surface on the canal side of the I-wall. The cofferdam wall consists of 12 to 16 feet sheet piling driven into the east side slope of the canal. The design did not include any forces from supporting the formwork.

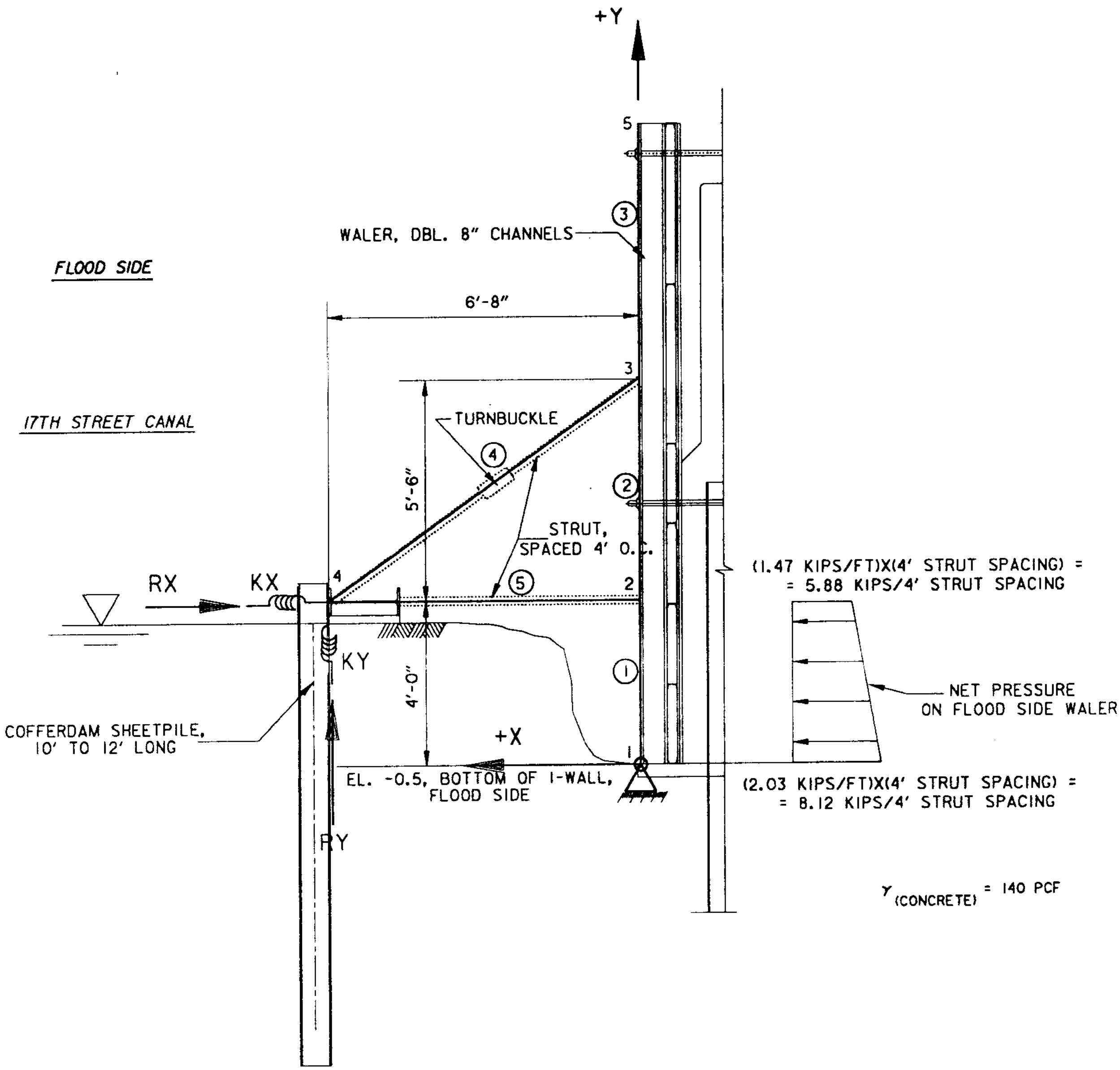
Formwork Support System Analysis

The formwork support system was analyzed using the WES computer programs, X0030, "Computer Program with Interactive Graphics for Analysis of Plane Frame Structures(CFRAME)" and "Design/Analysis of Anchored or Cantilever Sheet Pile Walls by Classical Methods (CWALSHT)".

In the CFRAME analysis we assumed that the bottom of the formwork is supported both vertically and horizontally and the formwork is rigid compared to the struts and support beam (See encl 1).

The analysis was done for the I-wall with wet concrete loading. The analysis showed that the formwork and the cofferdam will move towards the channel when the contractor placed concrete. The model included a vertical soil spring of 6 kips/4 ft./in. and a horizontal soil spring of 52 kips/4 ft./in. The vertical spring constant was determined using Bowles' 4th edition (See encl 2). The horizontal spring constant was determined by applying various horizontal loads to the CWALSHT program and calculating the spring constant from the resulting deflections (See encl 3).

Results:
1. Movement at the top of the formwork = 0.73" to the canal side.
2. Movement at the top of the cofferdam = 0.19" to the canal side.
3. Horizontal reaction at the top of the cofferdam = 9.91 kips/4' of wall.
4. Vertical reaction at the top of the cofferdam = 2.01 kips/4' of wall.
5. Net vertical movement at the top of the cofferdam = 0.33" downwards.



CFRAME MODEL

BETWEEN HAMMOND HIGHWAY AND
VET. HIGHWAY
17TH STREET CANAL, EAST BANK

encl 1

CALCULATION OF VERTICAL SUBGRADE REACTION

Reference FOUNDATION ANALYSIS AND DESIGN By Joseph E. Bowles 4th edition.

k_s = modulus of subgrade reaction, units are lbs/pcf (pg. 99)

$= \frac{\text{change in stress}}{\text{change in deformation}}$

$= \Delta q/\Delta H$ = stress increase in stratum from footing/settlement of foundation (pg. 407)

Approximation used by Bowles for horizontal or vertical subgrade reaction: $k_s = A_s + B_s Z^n$ (pg 408)

At ground surface $B_s Z^n = 0$; therefore $k_s = A_s$ for $\Delta H = 1$ inch, $k_s = 12A_s$

$k_s = 12A_s = 12(cN_c s_c + 0.5\gamma B N_\gamma s_\gamma)$ [Bearing Capacity Equation Bowles says either the Terzaghi or Hansen bearing capacity factors can be used. (pg. 408)]

$N_\gamma = 0$
$k_s = 12\ A_s = 12(cN_c)\ s_c = 1$ for strip footing
$12\ A_s = 12(255\ \text{psf})(5.7)$
$= 17{,}442\ \text{psf/ft} = 17.442\ \text{ksf/ft} = 17.442\ \text{kcf}$

For k/sf/inch: $k_s = 17.442\text{kcf}/12\ \text{in/ft} = 1.4535\ \text{ksf/in}$

For a 4 ft length

$k_s = (1.4535\ \text{ksf/in})(4\ \text{ft}) = 5.8\ \text{k/ft/in}$

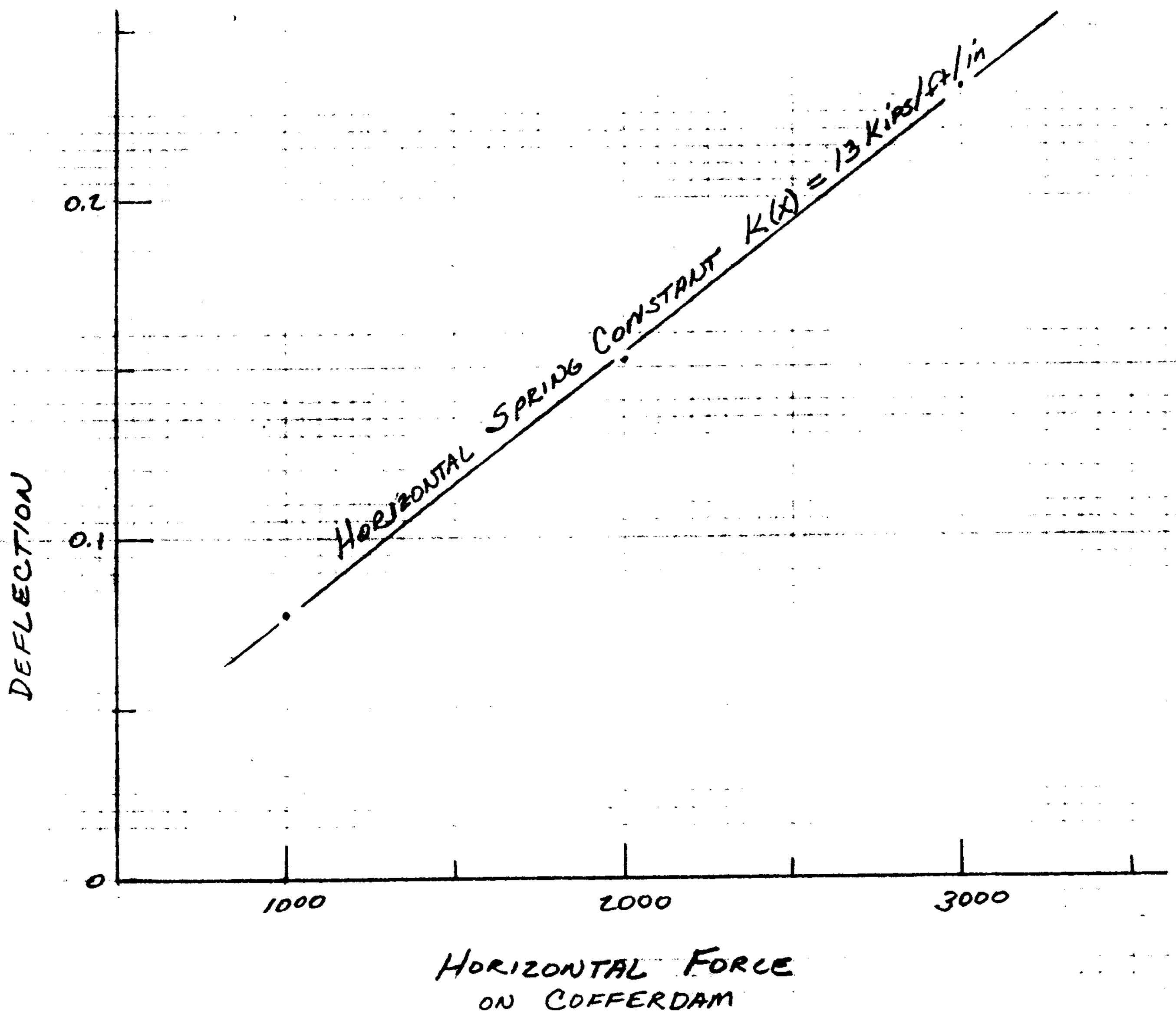
encl 2

BY JHR DATE 9/14/95 SUBJECT 17th Street Canal

East Bank Floodwall Capping

Canal Side Formwork Movement

CHKD. BY ____ DATE ____ SHEET NO. ____ OF ____ JOB NO. ____



ITERATIONS OF THREE LOADS APPLIED TO COFFERDAM TO DETERMINE SPRING CONSTANT FOR THE CFRAME PROGRAM.

encl 3

```
00100 17TH STREET CANAL, FORM ANALYSIS, BOTTOM FIXED, KX(4)=52 KY(4)=6
00110 KSI FT IN IN KIP
00120 5 5 1 29000 .3
00130 1 0 0 2 0 4 3 0 9.5 4 6.67 4 5 0 14.5
00140 FIX X 1 FIX Y 1
00145 FIX KX 52 4 FIX KY 6 4
00150 1 1 2 2 2 3 3 3 5 4 3 4 5 2 4
00160 6000 6.78 6.78 1 2 3
00170 0.868 1.48 1.48 4 5
00200 LOAD CASE 1 0 1 CONCR-HYD-STAT
00220 0 8.12 4 5.88 0 1
```

--*-*-*-*-*-*-*-*-*-*-*-*-*-*

PROGRAM CFRAME

--*-*-*-*-*-*-*-*-*-*-*-*-*-*

RUN DATE = 14-SEP-1995
RUN TIME = 09.50.17

17TH STREET CANAL, FORM ANALYSIS, BOTTOM FIXED, KX(4)=52 KY(4)=6

*** JOINT DATA ***

			------------------FIXITY------------------					
JOINT	X	Y	X	Y	R	KX	KY	KR
	--- FT ---					---KIP / IN---		IN-KIP/RAD
1	.00	.00	*	*				
2	.00	4.00						
3	.00	9.50						
4	6.67	4.00				.520E+02	.600E+01	
5	.00	14.50						

*** MEMBER DATA ***

MEMBER	END A	END B	LENGTH FT	I IN**4	A IN**2	AS IN**2	E KSI	G KSI
1	1	2	4.00	.6000E+04	.6780E+01	.6780E+01	.2900E+05	.1115E+05
2	2	3	5.50	.6000E+04	.6780E+01	.6780E+01	.2900E+05	.1115E+05
3	3	5	5.00	.6000E+04	.6780E+01	.6780E+01	.2900E+05	.1115E+05
4	3	4	8.65	.8680E+00	.1480E+01	.1480E+01	.2900E+05	.1115E+05
5	2	4	6.67	.8680E+00	.1480E+01	.1480E+01	.2900E+05	.1115E+05

*** LOAD CASE 1 CONCR-HYD-STAT

MEMBER	LA FT	PA KIP / FT	LB FT	PB KIP / FT	ANGLE DEG
1	.00	.8120E+01	4.00	.5880E+01	.00

1 LOAD CASE 1 CONCR-HYD-STAT

JOINT DISPLACEMENTS

JOINT	DX IN	DY IN	DR RAD
1	.0000E+00	.0000E+00	-.4239E-02
2	.2044E+00	.4901E-03	-.4186E-02
3	.4773E+00	.1164E-02	-.4156E-02
4	.1905E+00	-.3346E+00	-.4239E-02
5	.7266E+00	.1164E-02	-.4156E-02

MEMBER END FORCES

MEMBER	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN-KIP	MOMENT EXTREMA IN-KIP	LOCATION IN
1	1	.2008E+01	.1809E+02	.0000E+00	.2560E+03	28.80
	2	.2008E+01	.9906E+01	.1607E+03	.0000E+00	.00
2	2	.2006E+01	-.2436E+01	.1607E+03	.1607E+03	.00
	3	.2006E+01	.2436E+01	-.1051E+00	-.1051E+00	66.00
3	3	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.00
	5	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.00
4	3	-.3156E+01	.1639E-02	.1051E+00	.6494E-01	103.74
	4	-.3156E+01	-.1639E-02	.6494E-01	-.1051E+00	.00
5	2	-.7470E+01	-.1212E-02	.3210E-01	.3210E-01	.00
	4	-.7470E+01	.1212E-02	-.6494E-01	-.6494E-01	80.04

STRUCTURE REACTIONS

JOINT	FORCE X KIP	FORCE Y KIP	MOMENT IN-KIP
1	-.1809E+02	-.2008E+01	.0000E+00
4	-.9906E+01	.2008E+01	.0000E+00

TOTAL -.2800E+02 .0000E+00

1 MEMBER END FORCES

MEMBER	LOAD CASE	JOINT	AXIAL KIP	SHEAR KIP	MOMENT IN-KIP	MOMENT EXTREMA IN-KIP	LOCATION IN
1	1	1	.2008E+01	.1809E+02	.0000E+00	.2560E+03	28.80
		2	.2008E+01	.9906E+01	.1607E+03	.0000E+00	.00
2	1	2	.2006E+01	-.2436E+01	.1607E+03	.1607E+03	.00
		3	.2006E+01	.2436E+01	-.1051E+00	-.1051E+00	66.00
3	1	3	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.00
		5	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.00
4	1	3	-.3156E+01	.1639E-02	-.1051E+00	.6494E-01	103.74
		4	-.3156E+01	-.1639E-02	.6494E-01	-.1051E+00	.00
5	1	2	-.7470E+01	-.1212E-02	.3210E-01	.3210E-01	.00
		4	-.7470E+01	.1212E-02	-.6494E-01	-.6494E-01	80.04

```
100 '17th ST CANAL FILE: COFOAA'
110 'EAST STA 554+00 TO 589+00 PZ27 COFFERDAM'
130 CONTROL C A
140 WALL 4.5 -11.5 29000000 184.2
145 SURFACE RIGHTSIDE 3
180 0 2 5 2 7 -.8
190 SURFACE LEFTSIDE 4
200 0 1.5 4.5 0 35.7 -10.4 55.5 -18
210 SOIL RIGHTSIDE STRENGTH 2
215 153 153 0 200 0 0 0 0 0 0
230 103 103 0 200 0 0
210 SOIL LEFTSIDE STRENGTH 1
230 103 103 0 200 0 0
260 WATER ELEVATIONS 62.5 -1 1.5
265 HORIZONTAL LINE 1 3 2476
270 FINISH
```

Revise for c = 255 to give FS = 1

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 95/09/14 TIME: 10.30.23

****
* INPUT DATA *
****

I.--HEADING:
'17th ST CANAL FILE: COFOAA'
'EAST STA 554+00 TO 589+00 PZ27 COFFERDAM'

II.--CONTROL
CANTILEVER WALL ANALYSIS
SAME FACTOR OF SAFETY APPLIED TO ACTIVE AND PASSIVE PRESSURES.

III.--WALL DATA
ELEVATION AT TOP OF WALL = 4.50 (FT)
ELEVATION AT BOTTOM OF WALL = -11.50 (FT)
WALL MODULUS OF ELASTICITY = 2.90E+07 (PSI)
WALL MOMENT OF INERTIA = 184.20 (IN**4/FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	2.00
5.00	2.00
7.00	-.80

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	1.50
4.50	.00
35.70	-10.40
55.50	-18.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
153.00	153.00	.00	200.0	.00	.0	.00	.00		
103.00	103.00	.00	200.0	.00	.0				

V.B.-- LEFTSIDE LAYER DATA

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
103.00	103.00	.00	200.0	.00	.0				

VI.--WATER DATA

UNIT WEIGHT = 62.50 (PCF)
RIGHTSIDE ELEVATION = -1.00 (FT)
LEFTSIDE ELEVATION = 1.50 (FT)
NO SEEPAGE

VII.--SURFACE LOADS

NONE

VIII.--HORIZONTAL LOADS

VIII.A.--EARTHQUAKE ACCELERATION = .00 (G'S)

VIII.B.--HORIZONTAL LINE LOADS

ELEVATION (FT)	LINE LOAD (PLF)
3.00	2476.00

VIII.B.--HORIZONTAL DISTRIBUTED LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 95/09/14 TIME: 10.30.47

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL ANALYSIS *
****

I.--HEADING

'17th ST CANAL FILE: COFOAA'
'EAST STA 554+00 TO 589+00 PZ27 COFFERDAM'

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

FACTOR OF SAFETY : .77

MAX. BEND. MOMENT (LB-FT) : 9337.
AT ELEVATION (FT) : -2.72

MAXIMUM DEFLECTION (IN) : 1.9215E-01
AT ELEVATION (FT) : 4.50

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 95/09/14 TIME: 10.30.47

****
* COMPLETE RESULTS FOR *
* CANTILEVER WALL ANALYSIS *
****

I.--HEADING

'17th ST CANAL FILE: COFOAA'
'EAST STA 554+00 TO 589+00 PZ27 COFFERDAM'

III.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	NET DEFLECTION (IN)	PRESSURE (PSF)
4.50	0.	0.	1.9215E-01	.00
3.50	0.	0.	1.6745E-01	.00
3.00	0.	0.	1.5511E-01	.00
3.00	0.	2476.	1.5511E-01	.00
2.50	1238.	2476.	1.4278E-01	.00
2.00	2476.	2476.	1.3055E-01	.00
1.50	3714.	2476.	1.1852E-01	.00
1.50	3714.	2476.	1.1852E-01	-518.60
.50	5937.	1976.	9.5452E-02	-481.83
.00	6863.	1723.	8.4596E-02	-528.26
-.50	7656.	1448.	7.4295E-02	-574.70
-.99	8293.	1155.	6.4820E-02	-620.10
-1.00	8306.	1149.	6.4611E-02	-621.14
-1.50	8802.	834.	5.5598E-02	-636.33
-2.24	9243.	355.	4.3563E-02	-658.82
-2.50	9313.	183.	3.9732E-02	-666.70
-2.61	9329.	108.	3.8151E-02	-670.08
-2.72	9337.	33.	3.6586E-02	-673.50
-3.18	9289.	-235.	3.0691E-02	-509.63
-3.50	9187.	-392.	2.6860E-02	-459.96
-4.50	8554.	-885.	1.6948E-02	-526.19
-4.58	8481.	-928.	1.6271E-02	-532.76
-4.71	8356.	-995.	1.5219E-02	-507.57
-5.50	7428.	-1336.	9.7887E-03	-354.73
-5.65	7222.	-1387.	8.9253E-03	-325.46
-6.50	5947.	-1594.	5.0227E-03	-161.07
-7.49	4327.	-1658.	2.2040E-03	29.99
-7.50	4305.	-1658.	2.1761E-03	32.60
-7.57	4197.	-1655.	2.0444E-03	45.26
-7.73	3926.	-1645.	1.7385E-03	77.07
-8.16	3229.	-1594.	1.0947E-03	160.26
-8.38	2886.	-1555.	8.4491E-04	202.36
-8.50	2696.	-1528.	7.2304E-04	226.27
-9.50	1313.	-1205.	1.4813E-04	419.94
-9.72	1056.	-1107.	9.2940E-05	462.97
-10.50	350.	-689.	9.2251E-06	613.60
-10.85	150.	-465.	1.6210E-06	680.55
-11.30	11.	-132.	8.4967E-09	769.50
-11.47	0.	0.	0.0000E+00	802.00